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(54) Method of locating an object-applied code

(57) A method wherein an image (I) of an object bearing an optical code is divided (120) into a number of elementary images (If) for which a brightness gradient vector (G) is calculated (130). The calculated gradients (G) of a magnitude above (140) a given threshold value (Glim) are transformed (190) to eliminate the information relative to the direction of the vector, while maintaining the information relative to the path of the vector. The transformed (190) and quantized (200) vectors of a subimage (Ip) including a number of elementary images (If) are added (220) to calculate a total gradient vector, which is compared (230) with reference values to select (240) significant subimages containing a sufficient number of gradient vectors of substantially the same path.

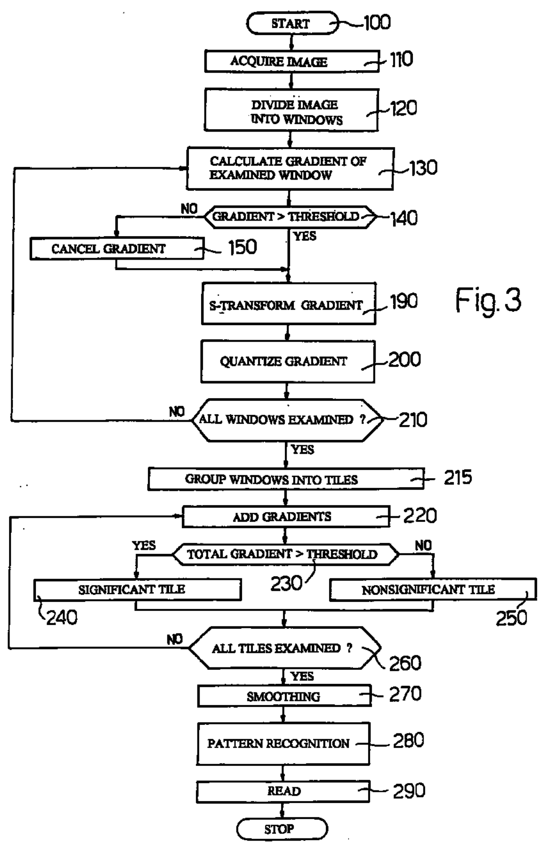

Fig.3

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Description

The present invention relates to a method of locating an object-applied optical code.

The present invention also relates to a device implementing the above method.

Systems are known for locating optical codes - in particular bar codes - applied to objects traveling on conveying devices (e.g. conveyor belts), and for determining the presence and arrangement in space of the code. Known devices normally use laser locating and reading systems, known types of which, however, present several drawbacks: poor reliability, due to the large number of moving mechanical parts involved; limited omnidirectional reading capacity; inability to read two-dimensional codes; and poor capacity for reading plastic-coated codes.

To overcome the above drawbacks, systems have been devised featuring optical sensors (in particular, telecameras) for picking up a two-dimensional image of the object and selecting a portion of the image corresponding to the code. Such systems also provide for reading the code in the selected image portion, but suffer from the drawback of involving complex processing of a large amount of data.

It is an object of the present invention to provide a method of locating an object-applied optical code, which provides for fast, effective location of the code.

According to the present invention, there is provided a method of locating an optical code applied to an object, characterized by comprising: an image acquisition step wherein at least one image (I) of an object bearing said code is acquired; a first processing step wherein the acquired image (I) is divided into a number of elementary images (If), each comprising a predetermined number (N) of pixels, and each pixel being assigned a pixel brightness value; a second processing step wherein a brightness gradient vector (G) is calculated for each of said elementary images (If); a first comparing step wherein, from said calculated gradient vectors (G), the vectors of a magnitude above at least one threshold value (Glim) and representing rapid variations in brightness are selected; a transforming step wherein the previously selected gradient vectors are transformed to determine a given path and a given direction, which path and which direction are assigned to all the calculated gradient vectors; a tiling step wherein said acquired image (I) is divided into a number of subimages (Ip), each comprising a number of elementary images (If); a composing step wherein the previously transformed gradient vectors of a selected subimage (Ip) are added to calculate a total gradient vector (Gs); a second comparing step wherein said total gradient vector (Gs) of each of said subimages (Ip) is compared with reference values to select significant subimages containing a sufficient number of gradient vectors having substantially the same path; the significant subimages being assigned a first binary logic value; said second comparing step also determining nonsignificant subimages containing a limited number of gradient vectors having substantially the same path; the nonsignificant subimages being assigned a second binary logic value; and said method generating at least one final binary image (Ir) representing said acquired image (I) divided into said subimages (Ip), each having a respective binary logic value.

If the optical code is a bar code, the angle (α) formed by said gradient vector with a cartesian reference system is preferably doubled during said transforming step.

During said transforming step, the angle (α) formed by said gradient vector with a cartesian reference system is preferably multiplied by a factor equal to the number of sides of the geometric figure forming the unit element of the optical code. More specifically, if the optical code is a two-dimensional code, the unit element of which is defined by four sides, said angle (α) is multiplied by a factor of four; if the unit element is defined by six sides, said angle (α) is multiplied by a factor of six.

The method according to the present invention provides for rapidly and effectively locating the acquired image portion corresponding to the code, so that the code reading algorithm only operates on the portions corresponding to the optical code image, and the amount of information for processing is greatly reduced as compared with that picked up by the telecamera. Moreover, no information is lost due to elision of vectors having the same path but opposite directions.

According to the present invention, there is also provided a device for locating an optical code applied to an object, characterized by comprising: image acquisition means for acquiring at least one image (I) of an object bearing said code; first processing means wherein the acquired image (I) is divided into a number of elementary images (If), each comprising a predetermined number (N) of pixels, and each pixel being assigned a pixel brightness value; second processing means wherein a brightness gradient vector (G) is calculated for each of said elementary images (If); first comparing means wherein, from said calculated gradient vectors (G), the vectors of a magnitude above at least one threshold value (Glim) and representing rapid variations in brightness are selected; transforming means wherein the previously selected gradient vectors are transformed to determine a given path and a given direction, which path and which direction are assigned to all the calculated gradient vectors; tiling means wherein said acquired image (I) is divided into a number of subimages (Ip), each comprising a number of elementary images (If); composing means wherein the previously transformed gradient vectors of a selected subimage (Ip) are added to calculate a total gradient vector (Gs); second comparing means wherein said total gradient vector (Gs) of each of said subimages (Ip) is compared with reference values to select significant subimages containing a sufficient number of gradient vectors having substantially the same path; the significant subimages being assigned a first binary logic value; said second comparing means also determining nonsignificant subimages containing a limited number of gradient vectors having substantially the same path; the nonsignificant subimages being assigned a second binary logic value; and said device generating at least one final binary image (Ir) representing said acquired image (I) divided into said subimages (Ip), each having a respective binary logic value.

If said code is a bar code, the transforming means preferably double the angle (α) formed by said gradient vector with a reference system.

Said transforming means preferably multiply the angle (α) formed by said gradient vector with a cartesian reference system by a factor equal to the number of sides of the geometric figure forming the unit element of the optical code. More specifically, if the optical code is a two-dimensional code, the unit element of which is defined by four sides, the factor equals four; if the optical code is a two-dimensional code, the unit element of which is defined by six sides, the factor equals six.

A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a schematic view of an automatic reading device implementing the method according to the present invention;
Figure 2 shows a circuit block diagram of a detail of the Figure 1 device;
Figure 3 shows the steps in the method according to the present invention;
Figures 4 to 12 show how the code locating method according to the teachings of the present invention operates.

Number 1 in Figure 1 indicates an automatic optical code reading device comprising a reading head 5 facing a conveyor belt 6 and for scanning objects 7 located on conveyor belt 6, traveling in a straight horizontal direction D, and each bearing an optical code on the surface 7a facing reading head 5. The term "optical code" is intended to mean a set of graphic marks on a label or directly on the object (or any other support), whereby information is coded in the form of a sequence of black and white or variously coloured regions arranged in one or more directions. Examples of optical codes are bar, two-dimensional and colour codes.

In the example shown, object 7 comprises a bar code BC in the form of a number of straight, parallel, alternating light and dark bars.

Device 1 comprises an electronic processing and control unit 12 cooperating with reading head 5.

Device 1 also comprises a sensor 14 located along conveyor belt 6 to determine the height of objects 7 traveling along the belt; a sensor 15 for determining the presence of objects 7 in the vicinity of reading head 5; and a speed sensor 16 for determining the traveling speed of the belt (and hence the conveyed objects) with respect to reading head 5.

Device 1 also comprises a lighting device 17 for lighting the belt portion scanned by reading head 5.

With reference to Figure 2, reading head 5 comprises a linear (e.g. CCD) telecamera 20 for scanning a line 6a of the belt (either continuously or when enabled by sensors 14, 15 and 16); and a circuit 22 for processing the output signals generated by telecamera 20. Circuit 22 comprises a filter 24 connected at the input to the output of telecamera 20; an image memory 26 connected at the input to the output of telecamera 20; and a programmable data processing unit (digital signal processor - DSP) 28 cooperating with filter 24 and memory 26.

Figure 3 shows a block diagram of the operating cycle of processing circuit 22.

More specifically, and as shown in Figure 3, a start block 100 goes on to a block 110, in which the lines 6a scanned by telecamera 20 are composed electronically to form a two-dimensional image (stored in memory 26) of conveyor belt 6 and/or objects 7, and so form a digital image I comprising a matrix of pixels, each characterized by a whole number defining its grey level. The acquired digital image I may comprise one or more objects 7 on conveyor belt 6, bearing one or more optical codes.

Block 110 is followed by a block 120, in which the acquired digital image I is divided into a number of elementary images (windows) If, each comprising a predetermined number N of pixels.

For example, windows If may comprise four pixels, as shown in Figure 4.

Block 120 is followed by a block 130, in which a brightness gradient vector G is calculated for each window If of image I.

In the example shown (four-pixel window), if A, B, C and D are the respective numeric values of the brightness of the pixels in the window, the gradient vector is calculated according to the following equations:

$$GX = C - B$$

$$GY = D - A$$

$$\alpha = \mathrm{arctg}(GY/GX)$$

where GX and GY are the components of gradient vector G along the X and Y axes (Figure 4), and α is the angle between the gradient and the X axis of a cartesian reference system, in which the X axis extends along the diagonals of pixels B,C, and the Y axis along the diagonals of pixels A,D.

Block 130 is followed by a block 140, which compares the magnitude of each calculated gradient vector with a threshold value Glim established at the initialization step. If the value of the gradient vector is below the threshold, block 140 goes on to a block 150, in which the gradient vector, considered nonsignificant by representing only gradual variations in brightness, is cancelled. Conversely (block 190 following block 140), the calculated gradient vector, considered significant by representing sharp variations in brightness, is kept for subsequent processing.

Block 190 performs a so-called "S-transform" of each previously calculated and selected gradient vector. More specifically, if the optical code is a bar code, angle α of each gradient vector is doubled (Figure 5).

The transformation operator in block 190 is capable of passing from gradient space (defined by magnitude, path and direction) to path space (defined by magnitude and path), so that, when S-transformed, two gradients of the same magnitude and path but opposite directions are mapped in the same path space vector. If the S-transform were not performed, in fact, the mean of two vectors of the same magnitude and path but opposite directions would obviously give a zero result, and the information associated with the gradients would be lost. To locate a bar code, which comprises a number of black bars alternating with white spaces, both black to white and white to black transitions, i.e. vectors of opposite directions, must be taken into account.

Two gradient vectors G1 and G2 of the same magnitude and path but opposite directions have the same magnitude $|G|$ and respective angles α_1 and α_2, where $\alpha_2 = \alpha_1 + 180°$. When S-transformed, the angle of vector G1 equals $2\alpha_1$, and the angle of vector G2 equals $2\alpha_2 = 2(\alpha_1 + 180°) = 2\alpha_1 + 360°$, i.e. vector G1 is now parallel to vector G2 and has the same direction.

Other two-dimensional optical codes, such as so-called "ID-MATRIX" codes, comprise square black or white unit elements, and involve identifying changes in brightness from white to black and black to white in four perpendicular directions, i.e. identifying four gradient vectors of the same magnitude and at 90° to one another (i.e. having respective angles α, α+90°, α+180°, α+270°). In this case, the S-transform in block 190 multiplies the angles of the four gradient vectors by 4 to generate four gradients, all with the same path 4α; and the four S-transformed vectors are added to give a vector of four times the magnitude of the gradient vectors and path 4α.

Other two-dimensional codes, such as "MAXI-CODES", comprise hexagonal black or white unit elements, and involve identifying changes in brightness from white to black and black to white in six directions to give six gradient vectors of the same magnitude and at 60° to one another (i.e. having respective angles α, α+60°, α+120°, α+180°, α+240°, α+300°). In this case, the S-transform in block 190 multiplies the angles of the six gradient vectors by 6 to generate six gradients, all with the same path 6α; and the six S-transformed vectors are added to give a vector of six times the magnitude of the gradient vectors and path 6α.

Generally speaking, for any type of two-dimensional optical code, the S-transform multiplies the angles of the gradient vectors by a factor equal to the number of sides of the unit element of which the code is formed. More specifically, the S-transform provides for transforming the previously selected gradients to determine a predetermined path and direction, which are assigned to all the calculated gradient vectors.

Block 190 is followed by a block 200, in which each gradient vector G transformed in block 190 is approximated to the closest of a set of reference vectors (gradient vector quantization). The reference vector set may comprise four first unit vectors perpendicular to one another, and four second vectors perpendicular to one another and forming a 45° angle with the first vectors (Figure 6).

Block 200 is followed by a block 210, which determines whether all the windows If defined in block 120 have been examined (and the relative gradient vectors calculated). In the event of a negative response (windows If still being examined), block 210 goes back to block 130 to calculate a further gradient vector. Conversely (windows If all examined), block 210 goes on to block 215.

Block 215 groups the quantized gradients of image I into a number of subsets (subimages) or tiles Ip, which are formed by dividing the acquired image I into a number of subimages (tiles) Ip, each comprising a number of windows If. For example, tiles Ip may comprise a hundred pixels of the original image I, and therefore (in the example shown) twenty-five windows If (each comprising four pixels).

The next processing step provides for determining which portions of the digitized original image I contain gradient vectors indicating brightness transitions compatible with the type of optical code being located. For example, a bar code, comprising parallel, side by side black and white bars, involves identifying white to black and black to white brightness changes in two directions to give two gradient vectors of the same path but opposite directions.

Block 215 is followed by a block 220, which adds the gradient vectors processed in blocks 190, 200 and forming part of a subimage Ip. That is, the S-transformed and quantized gradient vectors of the various windows If are composed to generate a total gradient vector Gs relative to the currently selected tile Ip.

Block 220 is followed by a block 230, in which the total gradient vector Gs is compared with threshold values. If the total gradient vector Gs exceeds the threshold values, block 230 goes on to block 240. Conversely (total gradient vector Gs below the threshold values), block 230 goes on to block 250.

In an X,Y cartesian reference system, the threshold values may be represented by the sides of a square Q (Figures 7 and 8). In which case, if one end of total gradient vector Gs falls within square Q (Figure 8), block 230 goes on to block 250. Conversely (end of total gradient vector Gs outside square Q - Figure 7), block 230 goes on to block 240. Figures 7 and 8 also show a square Q_2 representing the maximum possible value of total gradient vector Gs.

The situation determined in block 240 is that in which the value of the total gradient vector in the path space exceeds the threshold, in which case, the tile Ip in question is considered significant by comprising a sufficient number of gradient vectors of significant magnitude and substantially the same path (possible presence of an optical code and, in the example described, of a bar code). The selected tile Ip is therefore assigned a first logic value (in particular, a logic "1") indicating tile Ip is to be considered significant.

The situation determined in block 250 is that in which the value of the total gradient vector in the path space is below the threshold, in which case, the tile in question is considered nonsignificant by comprising an insufficient number of gradients of significant magnitude and substantially the same path. The selected tile is therefore assigned a second logic value (in particular, a logic "0") indicating tile Ip is to be considered nonsignificant.

Blocks 240, 250 are followed by a block 260, which determines whether all the tiles Ip of image I have been examined. In the event of a negative response (image still being examined), block 260 goes back to block 220 to examine a further tile Ip. Conversely (examination of image I completed), block 260 goes on to block 270.

The output of block 260 is a final binary image Ir (Figure 9) showing image I divided into a number of contiguous tiles Ip, each of which has a logic value "1" (significant "black" tile) if probably containing optical code images, or a logic value "0" (nonsignificant "white" tile) if probably containing no optical code images. The elementary unit by which final image Ir is represented is the same size as tile Ip. That is, tiles Ip constitute the pixels of final image Ir.

The final image Ir is supplied to the next block 270, which provides for further reducing the amount of information for subsequent processing, in addition to the gradual, drastic reduction already made by the above process up to this point.

The operation performed in block 270 (known as SMOOTHING) replaces the binary value of an original tile Ip in final image Ir with that of the majority of adjacent tiles, and provides for limiting the effect of acquisition noise and eliminating any "unclear" portions of the image. In the case of block 270 (Figure 10), smoothing provides for eliminating any small-area or narrow clusters (shown by the hatched portions in Figure 10). The elementary unit by which final image Ir is represented obviously remains the same size as tile Ip, and noise is reduced at the expense of a loss in clearness of the image.

At this point, the final image Ir, smoothed as described above, clearly shows the possible code portions, but still comprises apparently significant spurious portions (i.e. "black" tiles) not actually corresponding to bar codes and containing a large number of parallel gradients (e.g. portions relative to tables, labels, photographs, etc.).

The next block 280 provides (in known manner) for automatically recognizing the spurious portions and selecting the portions corresponding to the bar code by means of an automatic pattern recognition process for discriminating between the spurious portions and those corresponding to the bar code.

The step performed in block 280 provides for recognizing all the groups of significant ("black") tiles most likely to correspond to a bar code.

Possible ways of examining significant tile groups are:

- determining the area of the significant tile group, and rejecting any groups with an area below a first reference value or above a second reference value;
- determining the window defined by the significant tile group, and rejecting any defined windows of a size other than that of a possible code; and
- determining the barycenter of the significant tile group, and rejecting any groups with a barycenter at a distance from the center of the defined window over and above a given threshold value.

Block 280 therefore rejects some significant tile groups, elects other significant tile groups as corresponding to optical codes, and generates a number of elected significant tile groups, each defining a portion of image I containing a respective optical code. To read the optical code, the read algorithm (block 290 downstream from block 280) then processes in known manner the portion of image I relative solely to the portions corresponding to the elected tile groups.

The method described above therefore provides for effectively and rapidly locating the portion corresponding to the optical code in the image picked up by telecamera 20. As opposed to processing the whole digitized image I, the code reading algorithm (block 290) only processes the portions corresponding to the optical code image, thus greatly reducing the amount of information processed as compared with the amount acquired by the telecamera. Moreover, the S-transform in block 190 prevents information being lost due to the elision of vectors of the same path but opposite directions, thus further enhancing the efficiency of the location method; and, as the method described groups the tiles regardless of the predominant path of the gradients in each tile, tiles with predominantly perpendicular gradients may be placed in the same group.

The method described above involves the processing of a large amount of data, and, as objects 7 are conveyed on belt 6 at high speed (about 1-3 meters a second), only a very limited amount of time is available in which to locate and subsequently read the code. As such, to further improve the processing speed of the method according to the present invention, the initial operations corresponding to blocks 130-250 of the present method and characterized by the processing of a large amount of data by means of fairly straightforward algorithms may be performed using electronic circuits (HARDWARE) implementing the operations. Conversely, the final operations corresponding to blocks 270-290 of the present method and characterized by the processing of a small amount of data using fairly complex algorithms may be performed by a program (SOFTWARE). More specifically, the gradient calculation in block 130 may be performed by a first circuit (not shown) defining two subtractors and a digital delay line, and generating components GX and GY of gradient vector G. The operations in blocks 140, 150, 190 and 200 may be performed by a second circuit (not shown) mainly comprising a memory, receiving components GX and GY, and generating components Sx and Sy of the S-transformed and quantized gradient vector. The operations in block 220 may be performed by a third circuit (not shown) comprising a digital filter, adders and delay lines, receiving components Sx and Sy, and generating the x and y components of the total gradient vector. And finally, the operations in blocks 230, 240 and 250 may be performed by a fourth circuit (not shown) receiving the x and y components of the total gradient vector, and comprising a comparator, a memory and a series of adders.

By way of an alternative, in block 230, the total gradient vector Gs may be compared with threshold values and a number of reference paths. That is, the cartesian space in which total gradient vector Gs is located may be divided into a central portion defining the limit values of the threshold vector, and into a number of radial portions outside the central portion and corresponding to respective total gradient vector paths. Each radial portion (and, hence, each total gradient vector path) corresponds to at least one respective binary plane in which the total gradient vector is mapped. More specifically, the orientation of the total gradient vector provides for selecting at least one respective binary plane comprising a number of tiles. Each tile is assigned a "1" or "0" according to whether the respective total gradient vector is respectively above or below the threshold, so as to build a number of binary images, each similar to the one in Figure 9, i.e. divided into a number of contiguous tiles Ip of logic "1" (significant "black" tile) or logic "0" (non-significant "white" tile).

In the Figure 11 example, the cartesian space in which total gradient vector Gs is located is divided into a central portion (defined by a square Q) defining the minimum threshold vector values, and into eight symmetrical radial portions Z_1-Z_8 outside square Q and corresponding to respective paths of total gradient vector Gs. Each radial portion (and, hence, each total gradient vector path) corresponds to two respective binary planes a-h in which the corresponding tile Ip is assigned a "1", whereas, in all the other planes, the corresponding tile Ip is assigned a "0", so as to build eight binary images, each similar to the one in Figure 9. The analysis performed in block 280 is repeated for each of the various binary planes to locate the groups of significant (black) tiles Ip corresponding to optical code images. The division into multiple planes, each corresponding to one path, provides for improving the selectivity of the location process.

Figure 12 shows said space divided into a larger number of radial portions than in Figure 11, and more specifically into twelve portions. In this case, too, the orientation of the total gradient vector Gs of each tile Ip is determined to locate the plane/s of the portion relative to total gradient vector Gs, and so build a number of binary images.

In a further variation, N binary plane smoothing may be replaced by a mean total vector operation.

In which case, each total vector Gs generated by block 220 for a tile Ip is replaced by the mean total vector of all the tiles within an adequate neighbourhood of the tile Ip in question (e.g. a neighbourhood of three by three tiles Ip). The resulting total vector may then be processed in the same way as previously (blocks 230, 240 and 250), i.e. compared with threshold values to determine the significant tile groups. In which case, the binary smoothing operation in block 270 may be dispensed with.

Clearly, changes may be made to the method as described and illustrated herein without, however, departing from the scope of the present invention.

Claims

1. A method of locating an optical code applied to an object (7), characterized by comprising:

- an image acquisition step (110) wherein at least one image (I) of an object (7) bearing said code (BC) is acquired;
- a first processing step (120) wherein the acquired image (I) is divided into a number of elementary images (If), each comprising a predetermined number (N) of pixels, and each pixel being assigned a pixel brightness value (A, B, C, D);
- a second processing step wherein a brightness gradient vector (G) is calculated for each of said elementary images (If);
- a first comparing step (140) wherein, from said calculated gradient vectors (G), the vectors of a magnitude above at least one threshold value (Glim) and representing rapid variations in brightness are selected;
- a transforming step wherein the previously selected gradient vectors are transformed to determine a given path and a given direction, which path and which direction are assigned to all the gradient vectors;

- a tiling step (180) wherein said acquired image (I) is divided into a number of subimages (Ip), each comprising a number of elementary images (If);
- a composing step (220) wherein the previously transformed gradient vectors of a selected subimage (Ip) are added to calculate a total gradient vector (Gs);
- a second comparing step (230) wherein said total gradient vector (Gs) of each of said subimages (Ip) is compared with reference values to select (240) significant subimages containing a sufficient number of gradient vectors having substantially the same path; the significant subimages being assigned a first binary logic value ("1"); said second comparing step (230) also determining (250) nonsignificant subimages containing a limited number of gradient vectors having substantially the same path; the nonsignificant subimages being assigned a second binary logic value ("0");

  said method generating at least one final binary image (Ir) representing said acquired image (I) divided into said subimages (Ip), each having a respective binary logic value.

2. A method as claimed in Claim 1, wherein said optical code is a bar code (BC), characterized in that the angle (α) formed by said gradient vector with a cartesian reference system is doubled during said transforming step.

3. A method as claimed in Claim 1, characterized in that, during said transforming step, the angle (α) formed by said gradient vector with a cartesian reference system is multiplied by a factor equal to the number of sides of the geometric figure forming the unit element of the optical code.

4. A method as claimed in Claim 3, wherein said optical code is a two-dimensional code having a unit element defined by four sides; characterized in that, during said transforming step, the angle (α) formed by said gradient vector with a cartesian reference system is multiplied by a factor of four.

5. A method as claimed in Claim 3, wherein said optical code is a two-dimensional code having a unit element defined by six sides; characterized in that, during said transforming step, the angle (α) formed by said gradient vector with a cartesian reference system is multiplied by a factor of six.

6. A method as claimed in any one of the foregoing Claims, characterized in that said transforming step (190) is followed by a quantizing step (200) wherein the calculated gradient vectors are approximated to the closest vector in a series of reference vectors.

7. A method as claimed in Claim 6, characterized in that said reference vectors comprise four first unit vectors perpendicular to one another, and four second vectors perpendicular to one another and forming an angle of 45° with the first vectors.

8. A method as claimed in any one of the foregoing Claims, characterized by comprising a further processing step (270) of said final binary image (Ir), wherein the binary value of each subimage is replaced by the binary value of the majority of the adjacent subimages.

9. A method as claimed in any one of the foregoing Claims, characterized by comprising a pattern recognition step (280), wherein said final image (Ir) is examined to determine the subimage groups of said first binary value;

   said pattern recognition step (280) distinguishing, from the recognized subimage groups, typical subimage groups having said first binary value and most likely corresponding to significant portions of said acquired image corresponding to digital code images.

10. A method as claimed in Claim 9, characterized in that said pattern recognition step (280) is followed by a reading step, wherein the code contained in said significant portions is read automatically.

11. A method as claimed in any one of the foregoing Claims, characterized in that, in said second comparing step, said total gradient vector (Gs) is compared with threshold values and with a number of reference paths;

    the cartesian space in which said total gradient vector (Gs) is representable being divided into a central portion defined by threshold values, and into a number of radial portions outside the central portion and corresponding to respective paths of the total gradient vector; each radial portion corresponding to at least one respective binary plane comprising a number of subimages, the binary value of which is determined by comparing said total gradient vector with said threshold values.

12. A method as claimed in any one of the foregoing Claims, characterized in that said composing step (220) is followed by a step wherein each total gradient vector (Gs) generated for a respective subimage (Ip) is replaced by the mean total gradient vector of all the subimages (Ip) within a predetermined neighbourhood of said subimage (Ip), to generate a composite total gradient vector;

    the composite total gradient vector being compared with threshold values in said second comparing step (230) to determine significant subimage groups.

13. A device for locating an optical code applied to an object (7), characterized by comprising:

- image acquisition means (22, 110) for acquiring at least one image (I) of an object (7) bearing said code (BC);
- first processing means (120) wherein the acquired image (I) is divided into a number of elementary images (If), each comprising a predetermined number (N) of pixels; and each pixel being assigned a pixel brightness value (a, B, C, D);
- second processing means wherein a brightness gradient vector (G) is calculated for each of said elementary images (If);
- first comparing means (140) wherein, from said calculated gradient vectors (G), the vectors of a magnitude above at least one threshold value (Glim) and representing rapid variations in brightness are selected;
- transforming means wherein the previously selected gradient vectors are transformed to determine a given path and a given direction, which path and which direction are assigned to all the calculated gradient vectors;
- tiling means (180) wherein said acquired image (I) is divided into a number of subimages (Ip), each comprising a number of elementary images (If);
- composing means (220) wherein the previously transformed gradient vectors of a selected subimage (Ip) are added to calculate a total gradient vector (Gs);
- second comparing means (230) wherein said total gradient vector (Gs) of each of said subimages (Ip) is compared with reference values to select (240) significant subimages containing a sufficient number of gradient vectors having substantially the same path; the significant subimages being assigned a first binary logic value ("1"); said second comparing means (230) also determining (250) nonsignificant subimages containing a limited number of gradient vectors having substantially the same path; the nonsignificant subimages being assigned a second binary logic value ("0");

  said device generating at least one final binary image (Ir) representing said acquired image (I) divided into said subimages (Ip), each having a respective binary logic value.

14. A device as claimed in Claim 13, wherein said optical code is a bar code (BC), characterized in that said transforming means double the angle (α) formed by said gradient vector with a reference system.

15. A device as claimed in Claim 13, characterized in that said transforming means multiply the angle (α) formed by said gradient vector with a cartesian reference system by a factor equal to the number of sides of the geometric figure forming the unit element of the optical code.

16. A device as claimed in Claim 15, wherein said optical code is a two-dimensional code having a unit element defined by four sides, characterized in that said factor equals four.

17. A device as claimed in Claim 15, wherein said optical code is a two-dimensional code having a unit element defined by six sides, characterized in that said factor equals six.

Fig.1

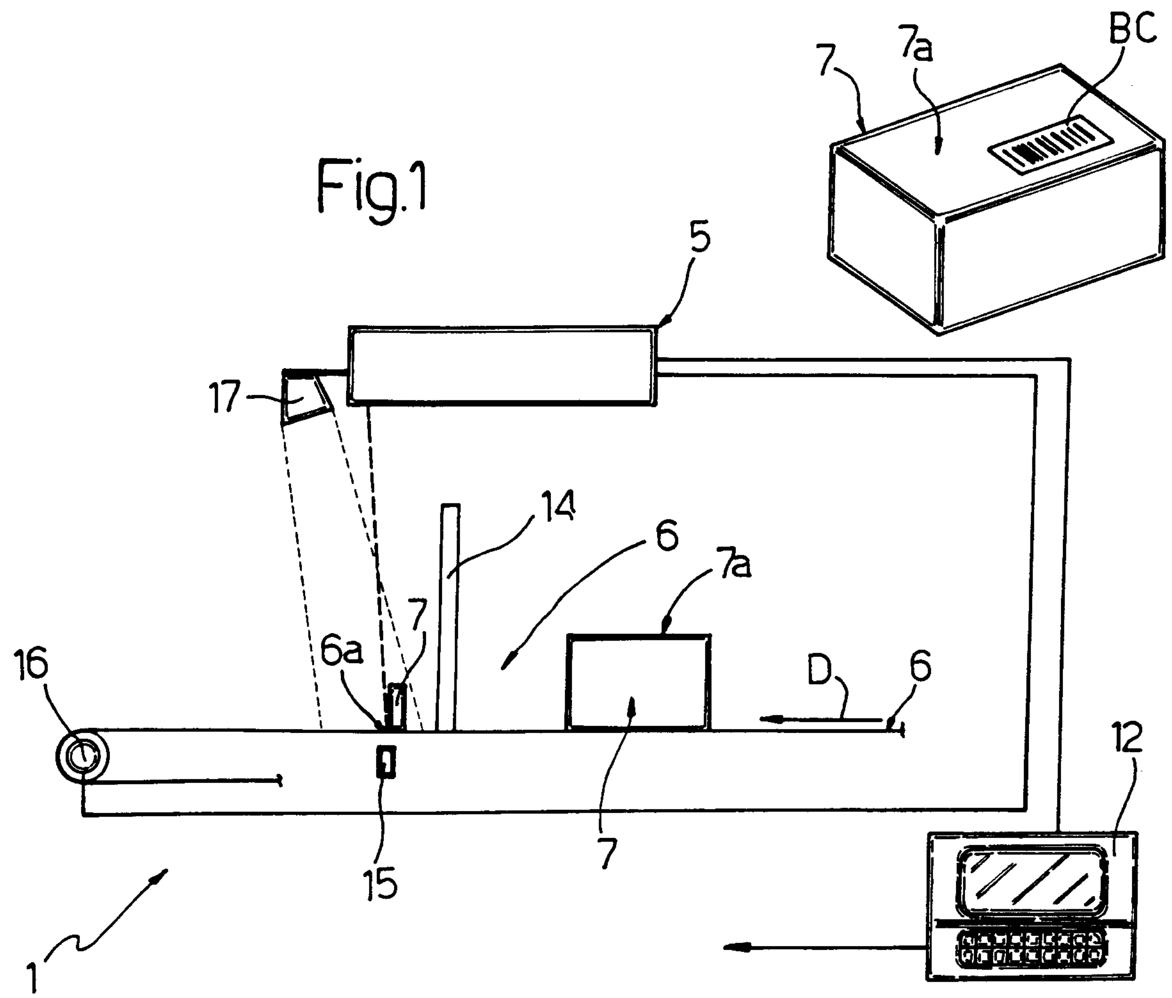
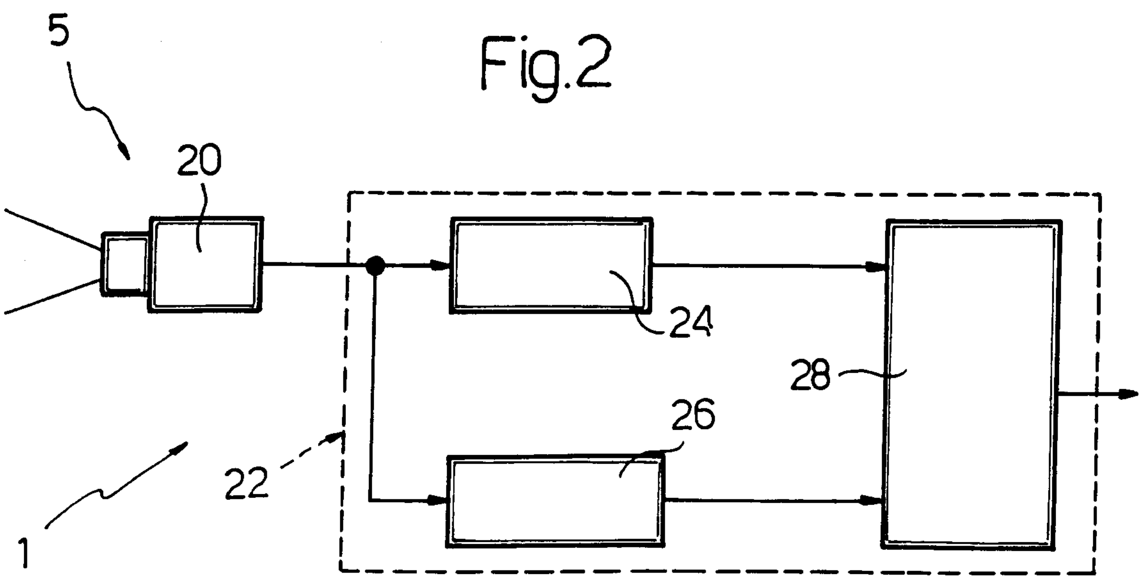


Fig.2



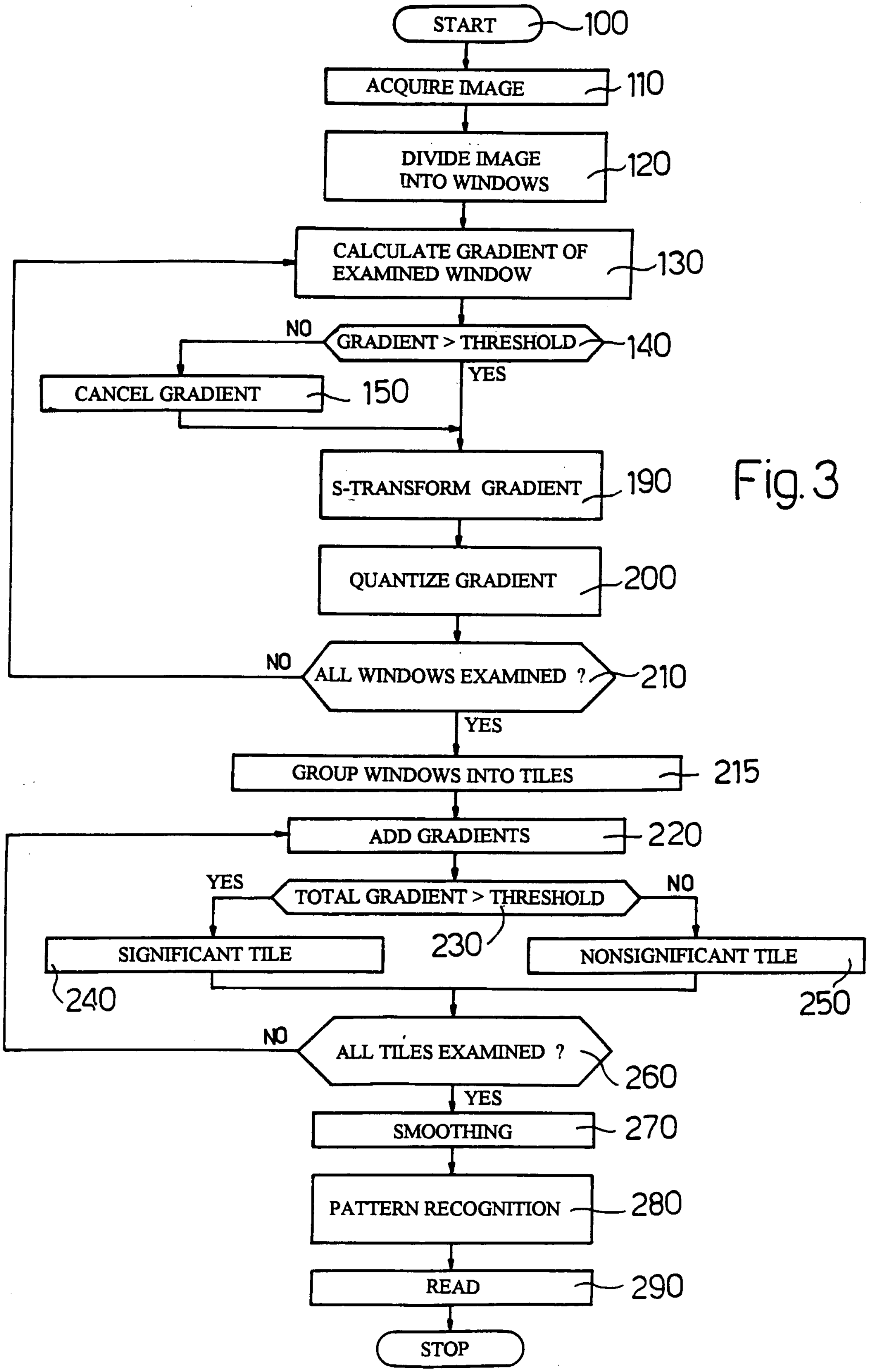

START
100
ACQUIRE IMAGE
110
DIVIDE IMAGE INTO WINDOWS
120
CALCULATE GRADIENT OF EXAMINED WINDOW
130
NO
GRADIENT > THRESHOLD
140
YES
CANCEL GRADIENT
150
S-TRANSFORM GRADIENT
190
QUANTIZE GRADIENT
200
NO
ALL WINDOWS EXAMINED ?
210
YES
GROUP WINDOWS INTO TILES
215
ADD GRADIENTS
220
YES
TOTAL GRADIENT > THRESHOLD
NO
230
SIGNIFICANT TILE
240
NONSIGNIFICANT TILE
250
NO
ALL TILES EXAMINED ?
260
YES
SMOOTHING
270
PATTERN RECOGNITION
280
READ
290
STOP

Fig. 3

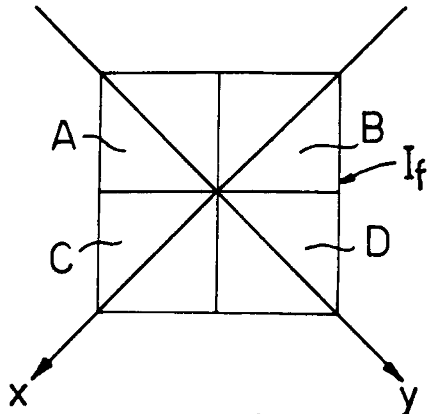


Fig.4

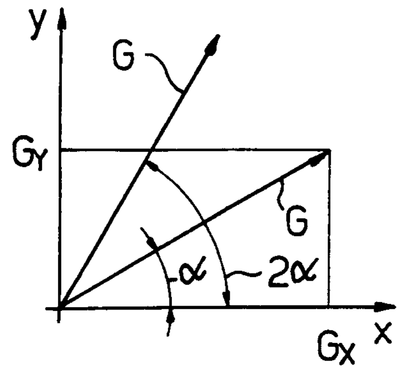


Fig.5

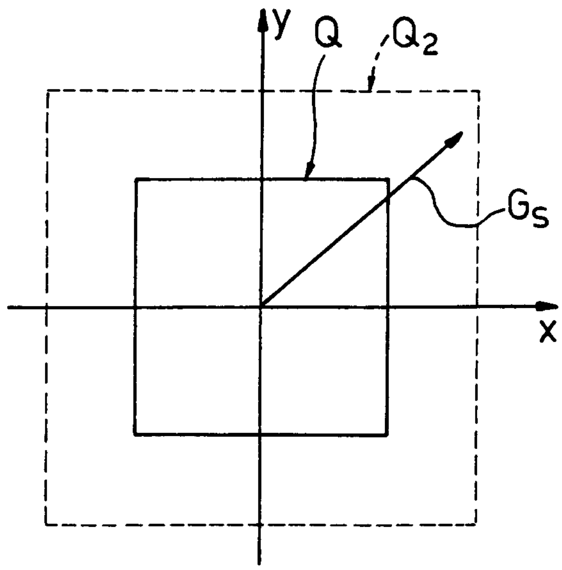


Fig.7

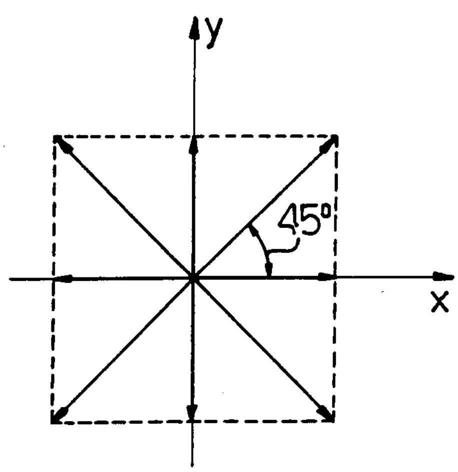


Fig.6

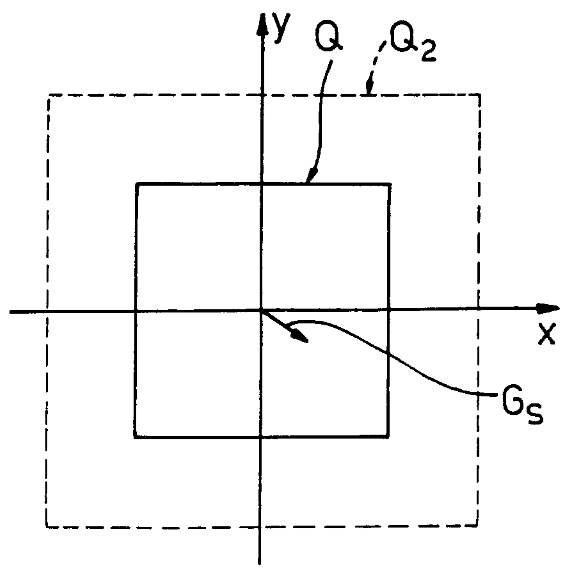


Fig.8

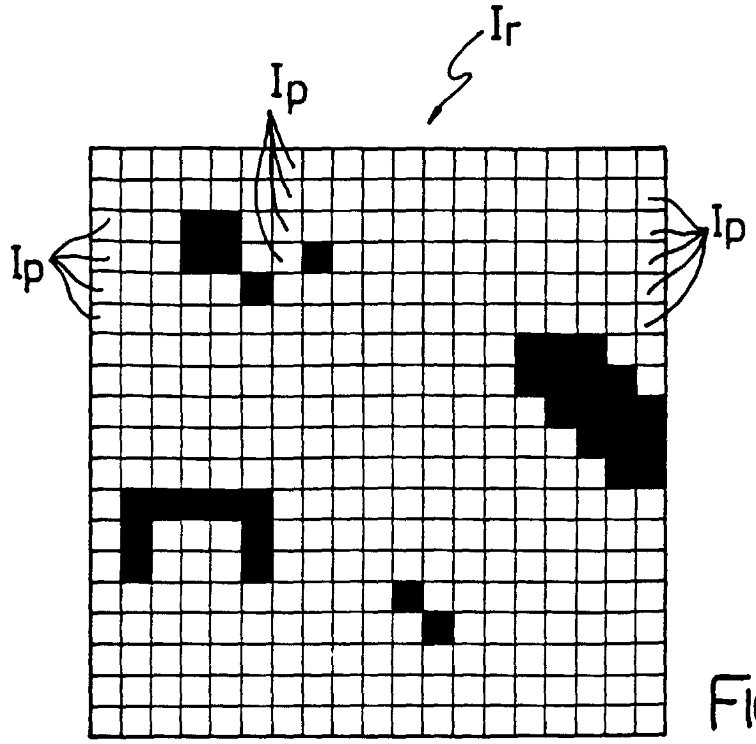


Fig. 9

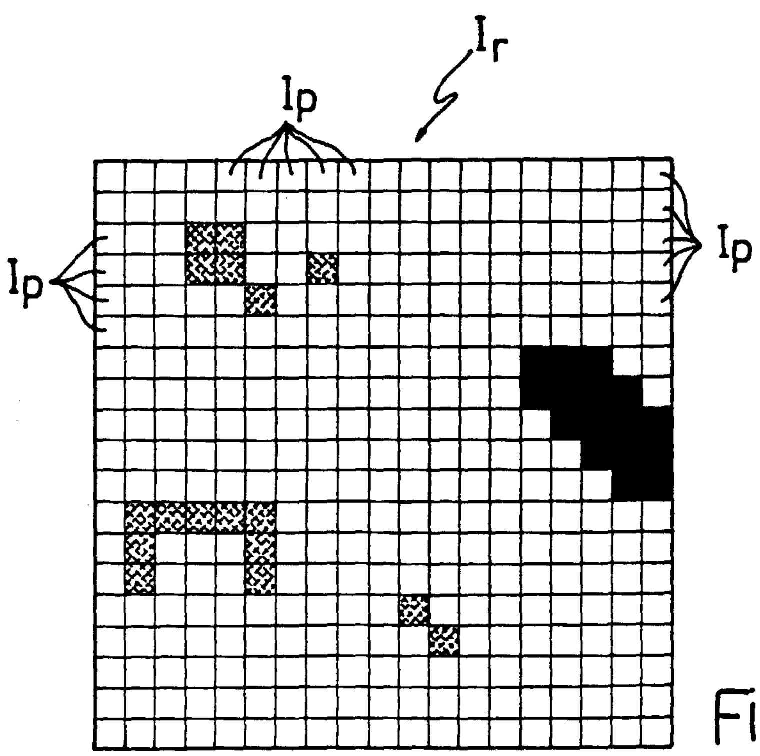


Fig. 10

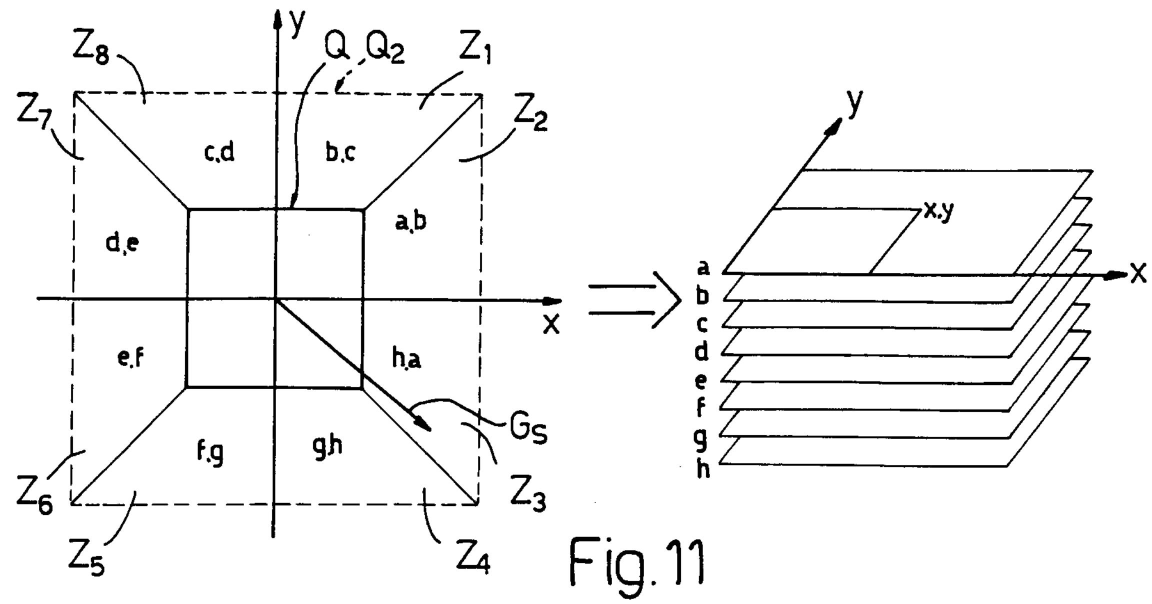

y
Z8
Q
Q2
Z1
Z7
Z2
c,d
b,c
a,b
d,e
x
e,f
h,a
Gs
f,g
g,h
Z6
Z3
Z5
Z4
y
x,y
x
a
b
c
d
e
f
g
h

Fig. 11

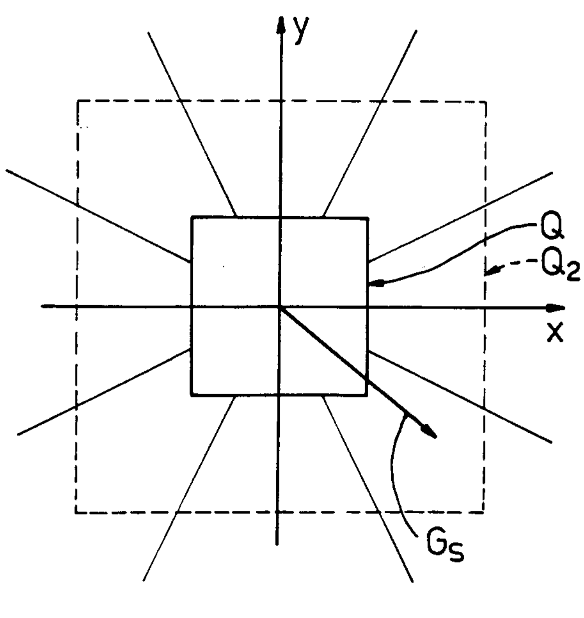

y
Q
Q2
x
Gs

Fig. 12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 83 0661

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 5 504 319 A (CHUNG-CHI J. LI ET AL.) * column 1, line 55 - line 67 * * column 3, line 37 - column 6, line 34; figures 1-11 *	1,13,16	G06K7/00 G06K7/10 G06K7/14
A	US 5 268 580 A (DUANFENG HE) * column 1, line 49 - column 2, line 5; figures 1-5 *	1,13	
A	US 5 304 787 A (YNJIUN P. WANG) * column 3, line 66 - column 5, line 6; figures 2,3A,3B *	1,13	
A	US 5 296 690 A (DONALD G. CHANDLER ET AL.) * column 5, line 15 - column 7, line 3; figures 3,4 *	1,13	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G06K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	5 May 1997	Ducreau, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document